



Complete, fold and seal
(see note 2 below)

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Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	P146322
2	Title of Examination Paper	ADVANCED VEHICLE DYNAMICS
3	Module Code	M6X00415
4	Date and Time of Examination	21/5/19 12:00
5	Examination Venue	IO310
6	Seat Number	G051
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	15 1/2
2	16
3	14 1/2
	46
Total	77



①

a

$$M = 1170 \text{ kg}$$

$$F = 58\%$$

$$R = 42\%$$

$$M_{\text{front}} = 1170 \times 0.58 = 678.6 \text{ kg}$$

$$M_{\text{rear}} = 1170 \times 0.42 = 491.4 \text{ kg}$$

$$b: 2.718 \times 0.58 = 1.58 \text{ m}$$

$$a: 2.718 \times 0.42 = \underline{\underline{1.14 \text{ m}}}$$

Due to increased mass bias

2/2

b

$$C = \frac{I}{Ma}$$

I is given
1300 kg.m²

$$I = MR^2$$

$$= (678.6 \times 1.14^2) + (491.4 \times 1.58^2)$$

$$= 2108.64 \text{ kg.m}^2$$

$$C = \frac{2108.64}{1170 \times 1.14}$$

$$\cancel{C = 1.58 \text{ m}}$$

error
carried

1/2

c

$$I = Mk^2$$

$$\frac{I}{M} = k^2$$

$$\sqrt{\frac{I}{M}} = k$$

$$\sqrt{\frac{2108.64}{1170}} = \underline{\underline{1.3 \text{ m}}}$$

1 1/2
2

①

$$DI = \frac{I}{m \times a \times b}$$

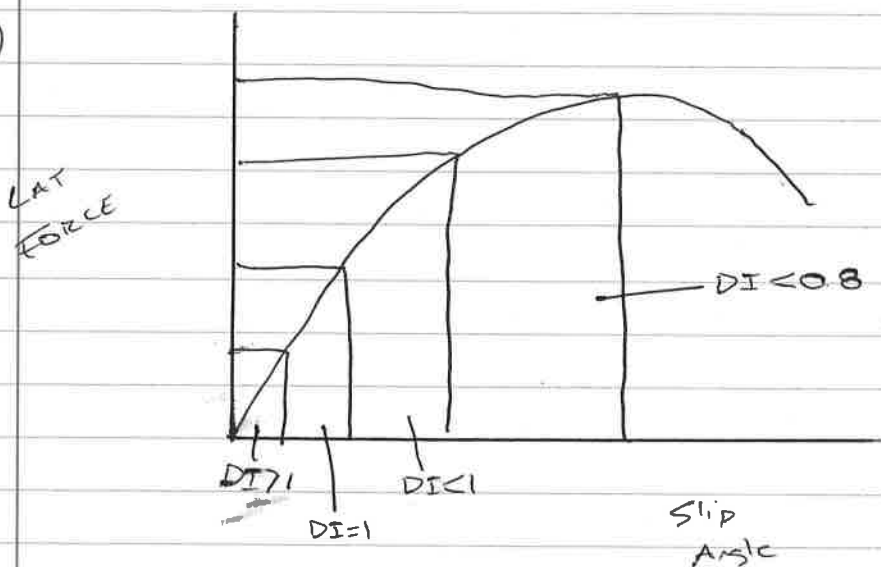
$$= \frac{2108.64}{1170 \times 1.14 \times 1.58}$$

$$= \underline{\underline{1}}$$

1 1/2 / 2

A $DI=1$ suggests the inertial conjugate is located on the rear axle. This will provide a moderate "predictable" turn in, though can be easily balanced.

②



If the $DI < 1$, initial turn in will be responsive and agile as the steering angle is applied, thus generating a slip angle, making the rear tyres travel outwards, building lateral grip. If further steering is applied, the slip angle is increased, though the lateral grip reduces as the tyres are on the limit of adhesion.

A $DI > 1$, initial turn in won't be so responsive as steering angle is applied, generating a slip angle, making the rear wheels travel in, generating lateral grip. If additional steering is applied, the slip angle is increased, generating further lateral grip as the tyres are on the limit of adhesion.

2 1/2 / 4

- (F) Two main sensor inputs exist, visual and audio. A time delay between these inputs and processing is apparent. Another time delay for when the brain processes a strategy response, and another delay for muscle response.

1/2

(G)

$$DI = 0.87$$

$$Old = 1300 \text{ kg m}^2$$

$$New = 1850 \text{ kg m}^2$$

①

$$I = Mk^2$$

$$DI = \frac{I}{m \times a \times b}$$

$$DI = \frac{Mk^2}{M \times a \times b}$$

$$DI = \frac{k^2}{a \times b}$$

$$\sqrt{DI \times a \times b} = k$$

$$k = \sqrt{0.87 \times 1.14 \times 1.58} = \underline{\underline{1.25 \text{ m}}}$$

✓ 3/3

② $1850 - 1300 = 550 \text{ kg m}^2$

$$\frac{550}{1.5^2} = 244.4 \text{ kg}$$

$$\frac{244.4}{2} = \underline{\underline{122.2 \text{ kg in each bumper}}}$$

3/3

15 1/2
20

②

$$a) \text{ Centripetal Accel} = \frac{V^2}{r}$$

$$V = (50000/60)/60 = 13.8 \text{ m/s} \quad \checkmark$$

$$\frac{13.8^2}{25} = \underline{\underline{7.6 \text{ m/s}^2}}$$

⑤

$$\text{Circum} = \pi \times 50 = 157 \text{ m}$$

$$\frac{157}{13.8} = 11.38$$

$$\frac{360}{11.38} = \underline{\underline{31.63^\circ/\text{s}}}$$

③

$$\frac{1500 \times 9.81}{4} = 3678.75 \text{ N}$$

$$\frac{M a_h}{t} = W T$$

$$\frac{750 \times 7.6 \times 0.6}{1.5} = 2280 \text{ N}$$

$$\text{Inner: } 3678.75 - 2280 = \underline{\underline{1398.75 \text{ N}}}$$

$$\text{Outer: } 3678.75 + 2280 = \underline{\underline{5958.75 \text{ N}}}$$

④

$$\text{Tractive Effort} = M g \mu$$

$$= 1500 \times 9.81 \times 0.013$$

$$= 191.3 \text{ N} \quad \checkmark$$

$$\text{Aero Effort} = \frac{1}{2} \rho C D A V^2$$

$$= 0.5 \times 1.2 \times 0.5 \times 3 \times 13.8^2$$

$$= 171.4 \text{ N} \quad \checkmark$$

$$\text{Total Effort} = 191.3 + 171.4 = \underline{\underline{362.7 \text{ N}}}$$

E

$$F = ma$$

$$F = 750 \times 7.6$$

$$F = \underline{\underline{5700 \text{ N}}}$$

1/1

F

$$750 \times 9.81 = 7357.5 \text{ N}$$

$$\text{Inner load \%} : \frac{1398.75}{7357.5} = 0.2$$

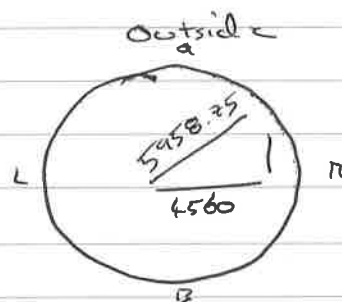
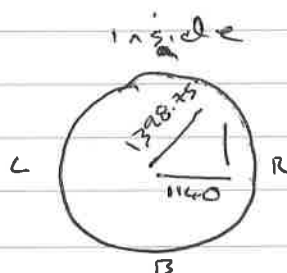
$$\text{Outer load \%} : \frac{5958.75}{7357.5} = 0.8$$

$$\text{Inner LAT Resis} = 0.2 \times 5700 = \underline{\underline{1140 \text{ N}}}$$

$$\text{Outer LAT Resis} = 0.8 \times 5700 = \underline{\underline{4560 \text{ N}}}$$

3/3

G



$$1398.75 \times 1 = 1398.75$$

$$5958.75 \times 1 = 5958.75$$

LONG FORCE

$$a = \sqrt{1398.75^2 - 1140^2}$$

$$a = \sqrt{5958.75^2 - 4560^2}$$

$$a = 810.5 \text{ N}$$

$$a = 3835.77 \text{ N}$$

Open Diff

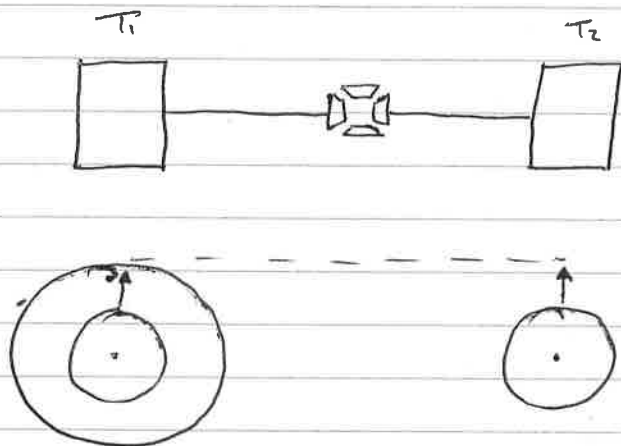
$$\text{So } T_1 = T_2$$

$$810.5 \times 2 = \underline{\underline{1621 \text{ N}}}$$

need to take off truck for drive

3/4

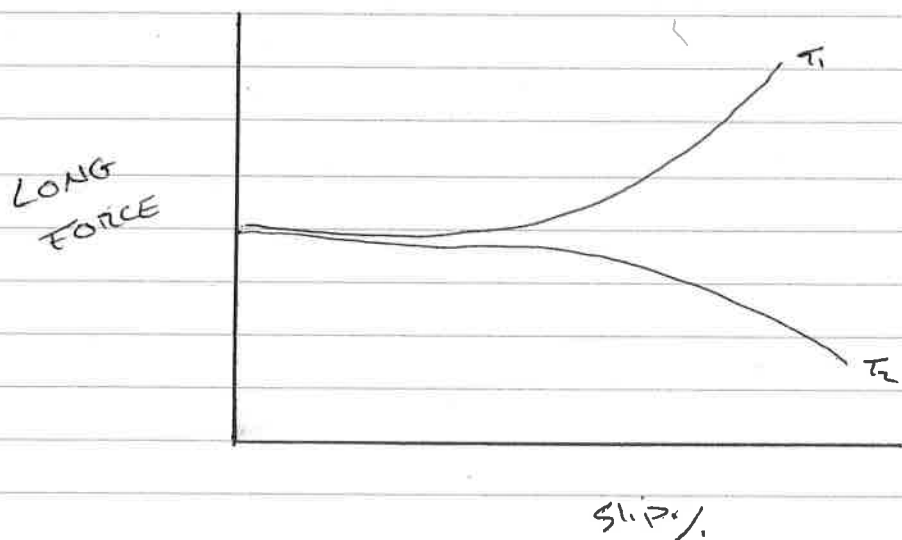
(H)



$$T_1 = T_2$$

$$T_1 = T_2 \text{ grip} \times 2$$

$$T_2 = T_2 \text{ grip}$$



1/4

16/20

③

a

$$F = Ma$$

$$750 \times 9.81 = 7357.5 \text{ N}$$

$$\text{Load for Each wheel} = 3678.75 \text{ N}$$

$$\text{Low } \mu \text{ side} = 3678.75 \times 0.05 = 183.94 \text{ N}$$

$$\text{High } \mu \text{ side} = 3678.75 \times 0.7 = 2575.13 \text{ N}$$

$$\left. \begin{array}{l} \text{Low } \mu = 183.94 \times 2 = 367.88 \text{ N} \\ \text{High } \mu = 2575.13 \times 2 = 5150.26 \text{ N} \end{array} \right\} \text{ Total / side}$$

~~Assuming~~

~~Assuming~~

$$5150.26 = 5518.14 \text{ N}$$

$$\text{Total} = 367.88 + 5518.14 = 5886.02 \text{ N}$$

$$5518.14$$

$$367.88$$

$$5886.02$$

$$1500$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$\frac{F}{m} = a$$

$$\frac{5886.02}{1500} = 3.92 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

$$3.68 \text{ m/s}^2$$

b

$$\text{Yaw Moment} = F \times d$$

$$d = \frac{1}{2} L$$

$$5150.26 - 367.88 = 4782.38 \text{ N}$$

$$\frac{1.5}{2} = 0.75 \text{ m}$$

$$T = 4782.38 \times 0.75$$

$$T = 3586.79 \text{ Nm}$$

c

$$\text{Rotational Accel}$$

$$I = 2200 \text{ kg m}^2$$

$$\frac{3586.79}{2200} = 1.63 \text{ rad/s}^2$$

① $F = ma$

$$T = F \times r$$

$$\text{Rear Mass} / \text{Total Mass} \times W$$

$$750 / 1500 \times 2.65 = 1.325m$$

$$\frac{3586.79}{1.325} = \underline{\underline{2707N}}$$

2/2

②

$$\frac{2707}{1000} = 2.7^\circ$$

$$\text{Ratio} = 15:1$$

$$2.7 \times 15 = 40.5^\circ \text{ of Hand Wheel Angle}$$

2/2

③

$$750 \times 9.81 = 7357.5N \checkmark$$

$$\text{Each Wheel} = 3678.75N$$

$$\text{Low side} = 3678.75 \times 0.1 = 367.88N$$

$$\text{High side} = 3678.75 \times 0.9 = 3310.88N$$

7357.5 each side

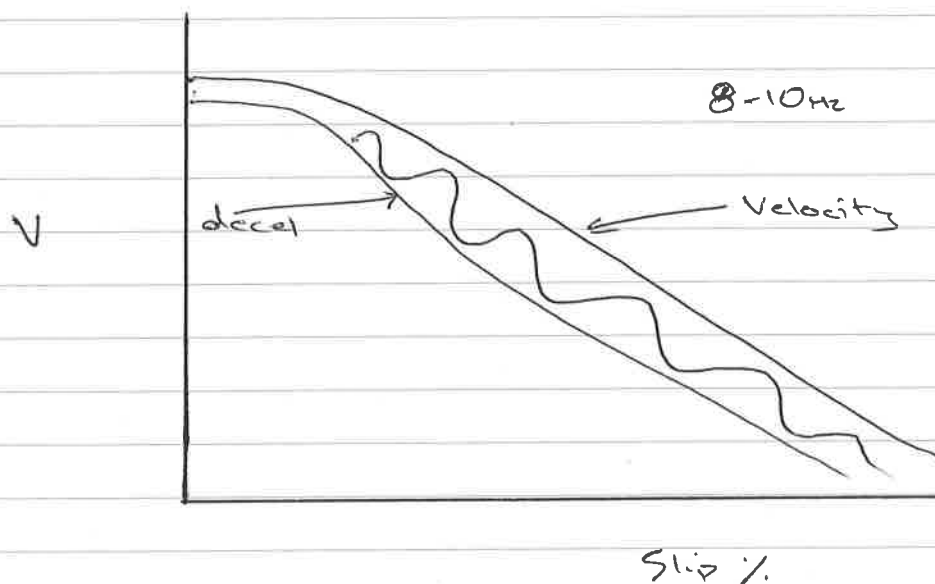
Add for total

$$(3310.88 \times 2) - (367.88 \times 2) = 5886N$$

$$\frac{5886}{1500} = \underline{\underline{3.92m/s^2 \text{ decel}}}$$

1 1/2 / 3

G



Using wheel speed sensors and gyros, An ABS system can detect if one wheel is rotating faster than another wheel and the additional Yaw moment this would have. By limiting the overall brake force to the lowest loaded wheel, ABS can control tyre slip and maintain traction. It does this by constantly varying brake force and distributing it to the necessary wheels. This maintains lateral stability though overall deceleration may be reduced.

$$\frac{2}{6}$$

$$\frac{14\frac{1}{2}}{20}$$

Question No.

Examiner On

Arholwr yn unig

ff y Cwestiwn